

SOLID PRECURSOR HEATING DEVICE FOR INDUCTION HEATING

BACKGROUND OF THE INVENTION

[0001] 1. Technical Field

5 [0002] The present invention relates to a heating device for use in producing a vapor-phase chemical reagent.

[0003] 2. Description of Related Art

 [0004] Vapor-phase reagents are used in vapor-utilizing processes in semiconductor manufacture and other similar industrial applications. These vapor-phase
10 reagents are produced by heating, and eventually sublimating, their respective solid precursors in a heating device.

 [0005] A conventional heating device for such a solid precursor uses a heating tape to heat the steel cylinder of the heating device through thermal conduction, and the steel cylinder conducts the heat received to the solid precursor in the steel cylinder in
15 order to sublime the solid precursor. Heating by thermal conduction, however, consumes a relatively large amount of thermal energy and has relatively low energy efficiency.

BRIEF SUMMARY OF THE INVENTION

 [0006] The primary objective of the present invention is to provide a solid
20 precursor heating device that has relatively high energy efficiency.

 [0007] To achieve the above and other objectives, the present invention provides a solid precursor heating device that includes a stainless steel cylinder (hereinafter also referred to as the steel cylinder for short), a plurality of vertically stacked trays, a buffering container, a pressure gage, and an induction heater. The steel cylinder has a
25 bottom plate, a peripheral wall, a cover, and a vapor output pipe. The bottom plate and the peripheral wall define an interior space. The cover is provided on a top portion of the

peripheral wall in a separable manner. The vapor output pipe is provided at the cover and is in communication with the interior space. The magnetic permeability of the stainless steel cylinder is higher than 1 H/m. The trays are provided in the interior space in a separable manner. Each tray has an accommodating space, a supporting plate, an annular side, and a circular ring, wherein: the accommodating space is defined between the supporting plate, the annular side, and the circular ring; the supporting plate is connected to a bottom portion of the annular side and is configured to support a solid precursor; the circular ring is connected to a top portion of the annular side; and the annular side is in close contact with the peripheral wall. The lowest one of the trays is defined as the bottom tray, and the supporting plate of the bottom tray does not have a hollow portion. The supporting plate of each tray other than the bottom tray rests on the circular ring of the tray immediately below. The buffering container has a buffering space, and the buffering space is fluidly connected to the interior space. The pressure gage is provided at the buffering container and is configured to sense the vapor pressure in the buffering space. The induction heater is in signal connection with the pressure gage and is configured to heat the steel cylinder, by induction heating, according to the vapor pressure sensed by the pressure gage.

[0008] The present invention is advantageous in that the stainless steel cylinder is suitable for induction heating, and that the relatively high magnetic permeability of the stainless steel cylinder helps increase energy efficiency.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0009] FIG. 1 is a schematic drawing of an embodiment of the present invention.

[0010] FIG. 2 is a perspective view of some of the components of the embodiment shown in FIG. 1.

[0011] FIG. 3 is an exploded view of some of the components of the embodiment

shown in FIG. 1.

[0012] FIG. 4 is a sectional view of some of the components of the embodiment shown in FIG. 1.

5 DETAILED DESCRIPTION OF THE INVENTION

[0013] Referring to FIG. 1 to FIG. 4 for an embodiment of the solid precursor heating device provided by the present invention for induction heating, the solid precursor heating device includes a steel cylinder 10, a plurality of vertically stacked trays 20a, 20b, and 20c, a buffering container 30, a pressure gage 40, and an induction heater 50.

10 **[0014]** The steel cylinder 10 has a bottom plate 11, a peripheral wall 12, and a cover 13. The bottom plate 11 and the peripheral wall 12 define an interior space 14. The cover 13 is provided on a top portion of the peripheral wall 12 in a separable manner. The steel cylinder 10 may further have a plurality of locking elements 15 for locking the cover 13 to the top portion of the peripheral wall 12. In addition, the steel cylinder 10 has a
15 vapor output pipe 16 provided in the cover 13, communicating with the interior space 14, and configured to output a vaporized chemical reagent. In a feasible mode of implementation, the steel cylinder 10 is made of stainless steel, and the magnetic permeability of the steel cylinder 10 (in particular of the peripheral wall 12) is preferably higher than 1 H/m, such as in the range from 1.04 to 1.05 H/m. In a feasible mode of
20 implementation, the stainless steel in use may contain the following ingredients: not more than 1 wt% of nickel (Ni), 17-20 wt% of chromium (Cr), 1.75-2.5 wt% of molybdenum (Mo), not more than 0.025 wt% of carbon (C), not more than 0.035 wt% of nitrogen (N), about 0.8 wt% of titanium (Ti) and niobium (Nb) in total, and iron (Fe) making up the remaining percentage. Preferably, the nickel content is not more than 0.6 wt%, the
25 chromium content is 17.5-19.5 wt%, and the nitrogen content is not more than 0.025 wt%. A stainless steel having the foregoing composition has good thermal conductivity and can

be heated efficiently by induction heating.

[0015] The trays 20a, 20b, and 20c are provided in the interior space 14 in a separable manner. Each tray 20a/20b/20c has an accommodating space 21, a supporting plate 22, an annular side 23, and a circular ring 24, wherein: the accommodating space 21 is defined between the supporting plate 22, the annular side 23, and the circular ring 24; the supporting plate 22 is connected to a bottom portion of the annular side 23 and is configured to support a solid precursor (e.g., a tungsten precursor or a molybdenum precursor) that can be heated and thereby vaporized into a vapor-phase chemical reagent; the circular ring 24 is connected to a top portion of the annular side 23; and the annular side 23 is in close contact with the peripheral wall 12 so that the heat of the steel cylinder 10 can be conducted to the trays. The lowest one of the trays is defined as the bottom tray 20c, and the supporting plate 22 of the bottom tray 20c does not have a hollow portion. The trays other than the bottom tray 20c (i.e., the trays 20a and 20b) each have their supporting plate 22 resting on the circular ring 24 of the tray immediately below. The uppermost one of the trays is defined as the top tray 20a, and the supporting plate 22 of the top tray 20a has a central hollow portion. There is at least one tray, defined as a middle tray 20b, between the bottom tray 20c and the top tray 20a (in this embodiment, there are a plurality of middle trays 20b). Provided at the center of the supporting plate 22 of each middle tray 20b are a vertical cylindrical member 25 that is open at the top end as well as at the bottom end and an inner circular ring 26 that extends radially outward from the top end of the vertical cylindrical member 25. The height of the vertical cylindrical member 25 of each middle tray 20b is less than the height of the annular side 23 of the middle tray 20b so that a vapor-phase chemical reagent can be output through the passageway formed by the vertical cylindrical members 25 and then through the vapor output pipe 16.

[0016] The buffering container 30 has a buffering space 31. The buffering space 31 is fluidly connected to the interior space 14 so that a vapor-phase chemical reagent can

be supplied from the interior space 14 into the buffering space 31. The pressure gage 40 is provided at the buffering container 30 and is configured to sense the vapor pressure in the buffering space 31. The induction heater 50 is in signal connection with the pressure gage 40 and is configured to heat the steel cylinder 10, by an induction heating method, according to the vapor pressure sensed by the pressure gage 40. More specifically, when the vapor pressure sensed is lower than the required vapor pressure range, the induction heater 50 either is started to heat, or increases its power of heating, the steel cylinder 10 directly; as a result, the solid precursor in the steel cylinder 10 is heated indirectly, producing more vapor-phase chemical reagent to be supplied to, for example, a vapor-utilizing process. When the vapor pressure sensed is higher than the required vapor pressure range, the induction heater 50 either is turned off or reduces its heating power, thereby reducing the heat supplied to the steel cylinder 10 and hence the production of the vapor-phase chemical reagent to be supplied to the vapor-utilizing process. The supply pressure of the vapor-phase chemical reagent can therefore be maintained more stably than achievable with the prior art, and this solves the problem of control delay, which is typical of the prior art. Moreover, the induction heating method used in the present invention has higher energy efficiency than the conventional method of heating a steel cylinder through thermal conduction.

WHAT IS CLAIMED IS:

1. A solid precursor heating device for induction heating, comprising:

a stainless steel cylinder having a bottom plate, a peripheral wall, a cover, and a vapor output pipe, wherein the bottom plate and the peripheral wall define an interior space, the cover is provided on a top portion of the peripheral wall in a separable manner, the vapor output pipe is provided at the cover and is in communication with the interior space, and the stainless steel cylinder has a magnetic permeability higher than 1 H/m; and

a plurality of vertically stacked trays provided in the interior space in a separable manner, wherein each said tray has an accommodating space, a supporting plate, an annular side, and a circular ring; wherein in each said tray, the accommodating space is defined between the supporting plate, the annular side, and the circular ring, the supporting plate is connected to a bottom portion of the annular side and is configured to support a solid precursor, the circular ring is connected to a top portion of the annular side, and the annular side is in close contact with the peripheral wall; wherein the lowest one of the trays is defined as a bottom tray, and the supporting plate of the bottom tray does not have a hollow portion; and wherein the supporting plate of each said tray other than the bottom tray rests on the circular ring of a said tray immediately below.

2. The solid precursor heating device for induction heating as claimed in claim 1, wherein the uppermost one of the trays is defined as a top tray, and the supporting plate of the top tray has a central hollow portion.

3. The solid precursor heating device for induction heating as claimed in claim 2, wherein there is at least one said tray between the bottom tray and the top tray, the at least one tray is defined as a middle tray, the supporting plate of the middle tray is centrally provided with a vertical cylindrical member and an inner circular ring, the vertical

cylindrical member has an open top end and an open bottom end, the inner circular ring extends radially outward from the top end of the vertical cylindrical member, and the vertical cylindrical member of the middle tray has a height less than a height of the annular side of the middle tray.